Subtractive Theory of Color

Introduction   Illustrators and painters use pigments to produce color and color combinations. This is known as the subtractive theory of color.

Subtractive theory of color   In the subtractive theory of color, color is produced by pigment or combinations of pigment. The three primary colors of the subtractive theory of color are red, yellow, and blue. Combining any two primaries produces secondary, and combining a secondary and a primary color produces a tertiary color. Combining all three primaries results in a grey or muddy brown mixture.

Primary colors   The primary colors in the subtractive theory of color are red, yellow, and blue. These colors are called primary because they cannot be produced by combining any other color. They are the basis on which all other colors are created.

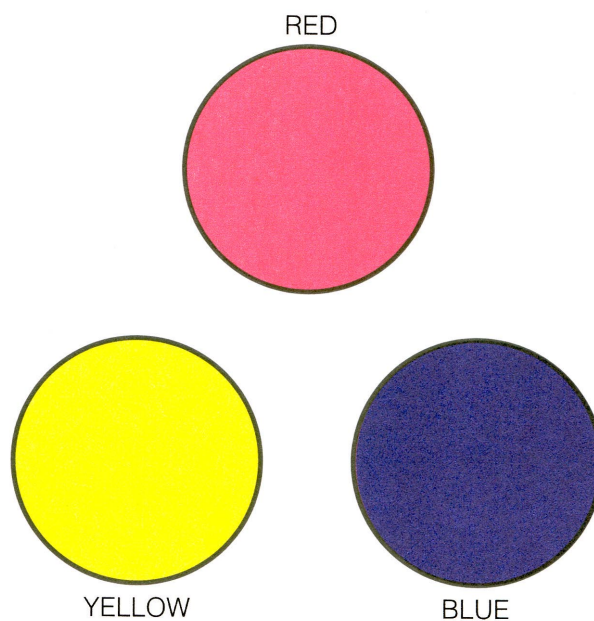Figure 2-8 shows the primary colors of the subtractive theory of color.

Figure 2-8.—Primary colors of the subtractive theory of color.

Subtractive Theory of Color, Continued

Secondary colors

Secondary colors are colors produced by combining two of the primary colors in equal amounts.   The secondary colors, also called binary colors, are violet, green, and orange. Primary and secondary colors are fundamental colors in the subtractive theory of color.

Figure 2-9 shows the secondary (binary) colors of the subtractive theory of color.
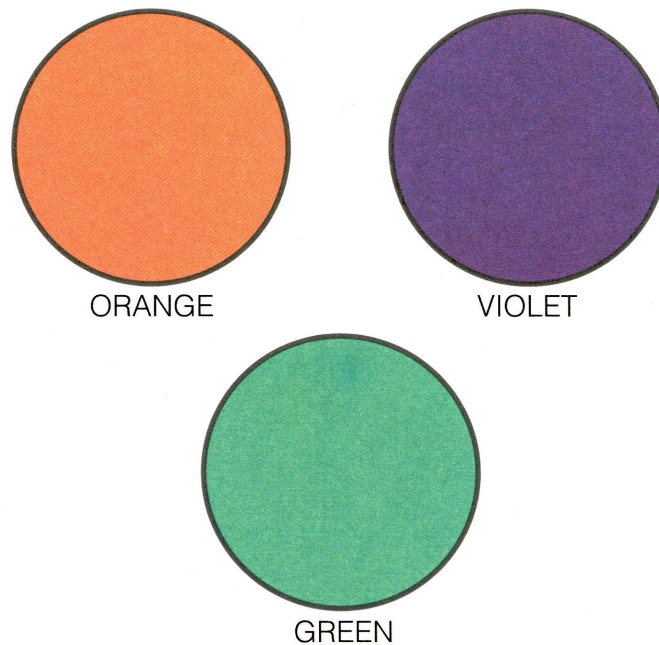
ORANGE   VIOLET

GREEN

Figure 2-9.—Secondary (binary) colors of the subtractive theory of color.

Subtractive Theory of Color, Continued

Tertiary colors   Tertiary colors are combinations of primary and secondary colors. There are six tertiary colors; red-orange, yellow-orange, yellow-green, blue-green, blue-violet, and red-violet. In compounding these names, such as "red" with "orange" to make "red-orange," place the primary name first to indicate an excess of the primary over the other color.

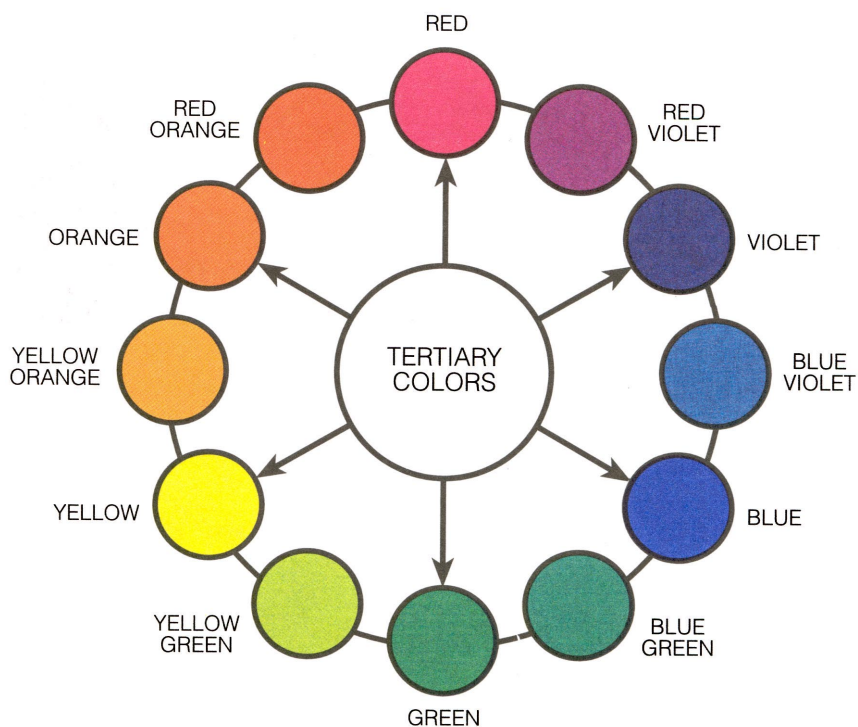Figure 2-10 shows tertiary colors.

Figure 2-10.—Tertiary colors.

Subtractive Theory of Color, Continued

Color wheel   A color wheel is a scale for measuring color. A fundamental color wheel displays primary and secondary colors. A 12-pigment color wheel accommodates the primary, secondary, and tertiary colors.
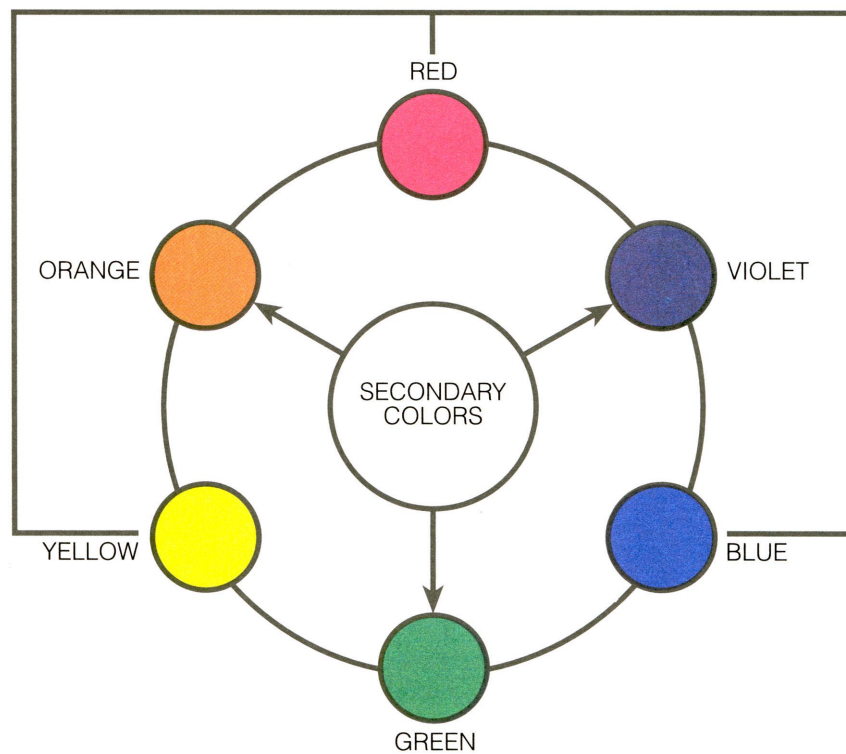
Figure 2-11 shows a fundamental color wheel.

Figure 2-11.—A fundamental color wheel showing primary and secondary (binary) colors.

Subtractive Theory of Color, Continued

Color Wheel (Continued)   Figure 2-12 shows a color wheel with the primary, secondary, and tertiary colors.
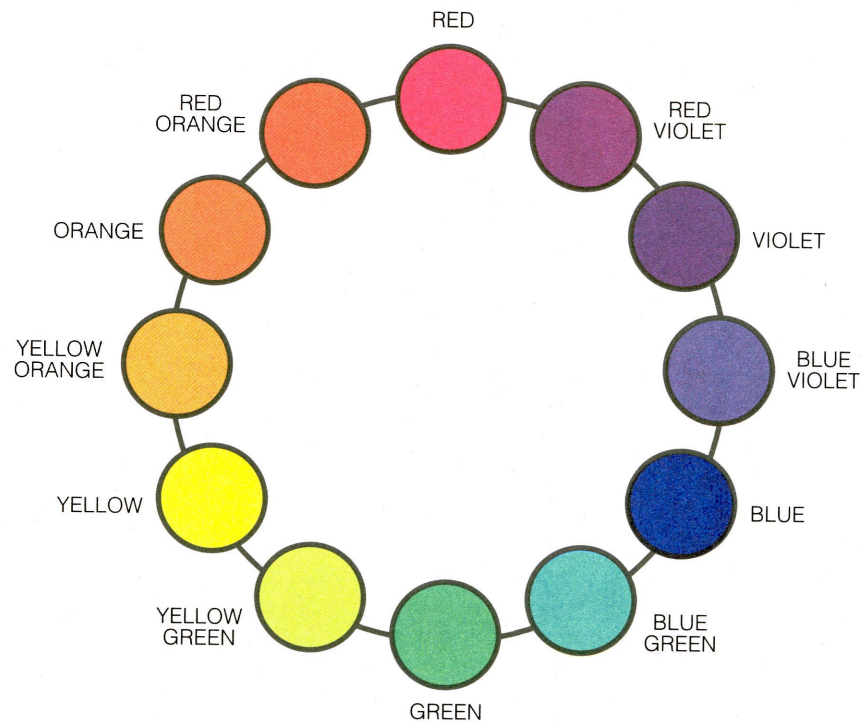

Figure 2-12.—A 12-hue color wheel.

Subtractive Theory of Color, Continued

|	
Proximity on the color wheel	A look at a 12-color color wheel easily identifies harmonious color combinations and complimentary colors.
Harmonious color	Harmonious colors are colors containing some part of the colors positioned next to them on the color wheel. Harmonious colors lie near each other on the color wheel. Although harmoniously colored images are generally pleasing to the eye, they can become monotonous.
Complimentary color	Complimentary colors lie directly across from each other on the color wheel. The compliment of red is green, of yellow is violet, and of blue is orange. Notice that the compliment of a primary color is a secondary color directly across from it on the color wheel. Complimentary colors are not related, but you can use them to create sharp contrasts or mix them to form a neutral grey.
Dimensions of color	The three dimensions of color are hue, value, and intensity. As an Illustrator Draftsman, you must understand each dimension to successfully analyze and mix colors for your illustrations.
Hue	Hue is the term used to name a color. How light or dark a color may be does not change hue. Hue is color before the addition of any other color. Figure 2-13 shows light and dark variations-of-a hue.
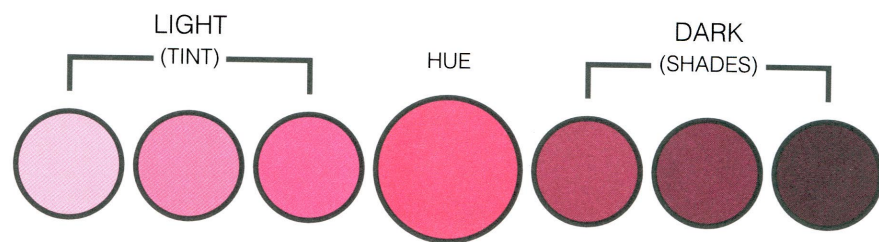
Figure 2-13.—Light and dark variations of the same hue.

Subtractive Theory of Color, Continued

Value
The second dimension of color is value. Value is the lightness or darkness of a hue. The terms tint and shade refer to the value of a color. You add white to a hue to create a tint. Add black to a hue to create a shade. In neither case has the hue changed, only its value and intensity. You must be able to decide the area that is the lightest and the area that is the darkest. Decide how light or dark an area is to be and relate all other values around this decision. When you decide on a value range or key, be consistent throughout the picture. Low-key value ranges are dark in value and high-key value ranges are bright or lightly colored.

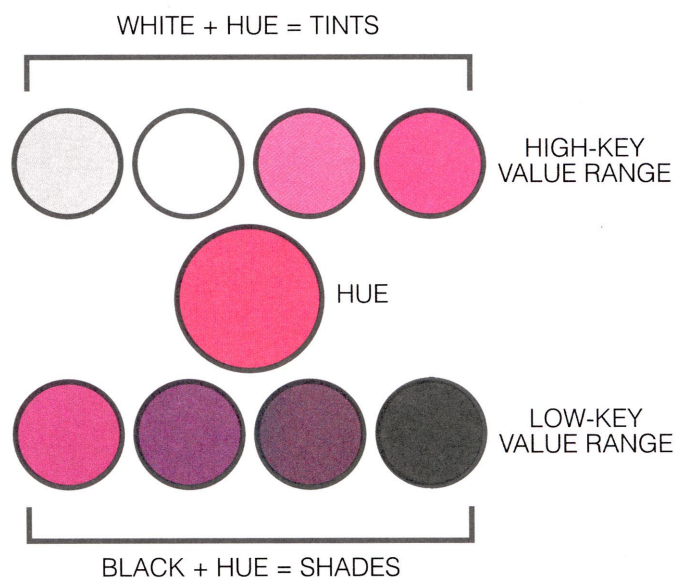Figure 2-14 shows a value scale or key.

WHITE + HUE = TINTS

HIGH-KEY VALUE RANGE

HUE

LOW-KEY VALUE RANGE

BLACK + HUE = SHADES

Figure 2-14.—Low and high key value ranges the same hue.

Subtractive Theory of Color, Continued

Intensity   The third dimension of color is intensity. Intensity, also known as chrome, refers to the degree of strength, saturation, or purity of colors. Pigment squeezed directly from the tube is at maximum intensity. Changing the value of pigment by adding white or black changes intensity but, not hue. You can also reduce the intensity of pigment without changing the value or hue by adding a neutral grey of equal value. Reducing the intensity of pigments by adding their compliment changes intensity and hue.

Color schemes   Before you start to paint, make small color thumbnail roughs. Try several color schemes to fit the subject. Use only general shapes and flat tones without detail. Use colors that add interest to your work. Certain color combinations are agreeable while others are offensive. Generally, color schemes will fit achromatic, monochromatic, analogous, complimentary, split complimentary, and triad color patterns.

Achromatic color schemes   Achromatic colors possess no hue. Neutral colors like white, grey, and black are achromatic. These neutral colors are far from being negative because they affect the appearance of other hues. Neutral colors are useful in modifying the values and intensities of all hues.

Figure 2-15 shows an achromatic color scheme.
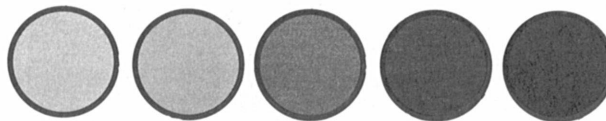
Figure 2-15.—An achromatic color scheme.

Subtractive Theory of Color, Continued

Monochromatic color schemes

The monochromatic color scheme is a single hue used in various tints, shades, and intensities. A monochromatic scheme is harmonious although there is nothing to which a monochromatic color scheme can disagree. One color having values ranging from light tints to dark shades can be colorful.

Figure 2-16 shows a monochromatic color scheme in blue.

Figure 2-16.—Monochromatic color.

Subtractive Theory of Color, Continued

Analogous color schemes

An analogous, or related, color scheme is made of hues near each other on the color wheel. They have a common denominator in one color. Out of the 12 hues on a b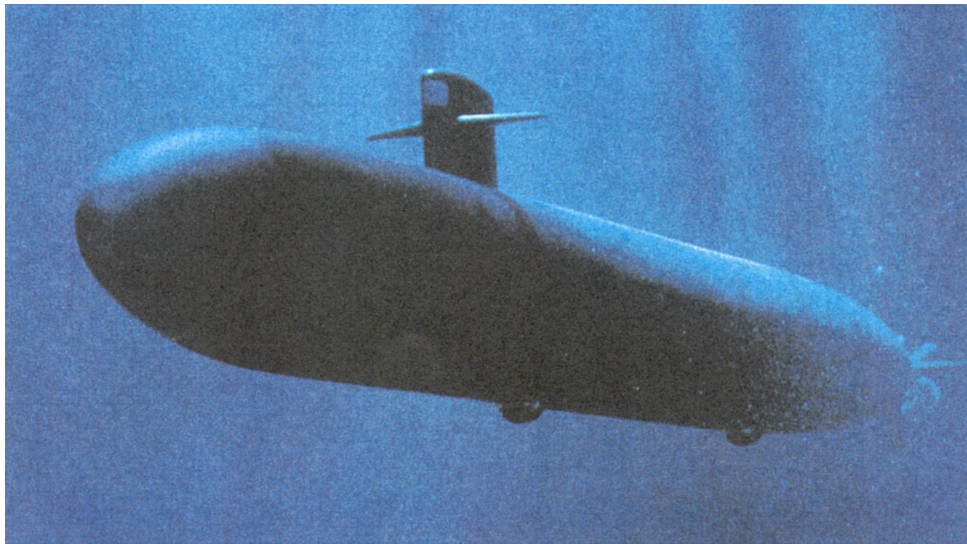asic color wheel, seven are related through one color.   A typical analogous color scheme should not contain more than three or four colors or you jeopardize harmony. Although analogous color schemes are easy to compose, they may become monotonous.   Use a variety of values, intensities, and arrangements to develop interest.   One of the easiest ways to obtain interest in analogous color schemes is to place emphasis on a dominant hue.   Some ways to make a particular hue dominant is to give it a large area, a darker value, or make it the most intense color. Avoid placing equally bright colors next to each other by adding small amounts of one color to the others. Another way to obtain interest in analogous color schemes is to introduce complimentary accents.

Figure 2-17 shows the analogous relationship of colors on a color wheel.
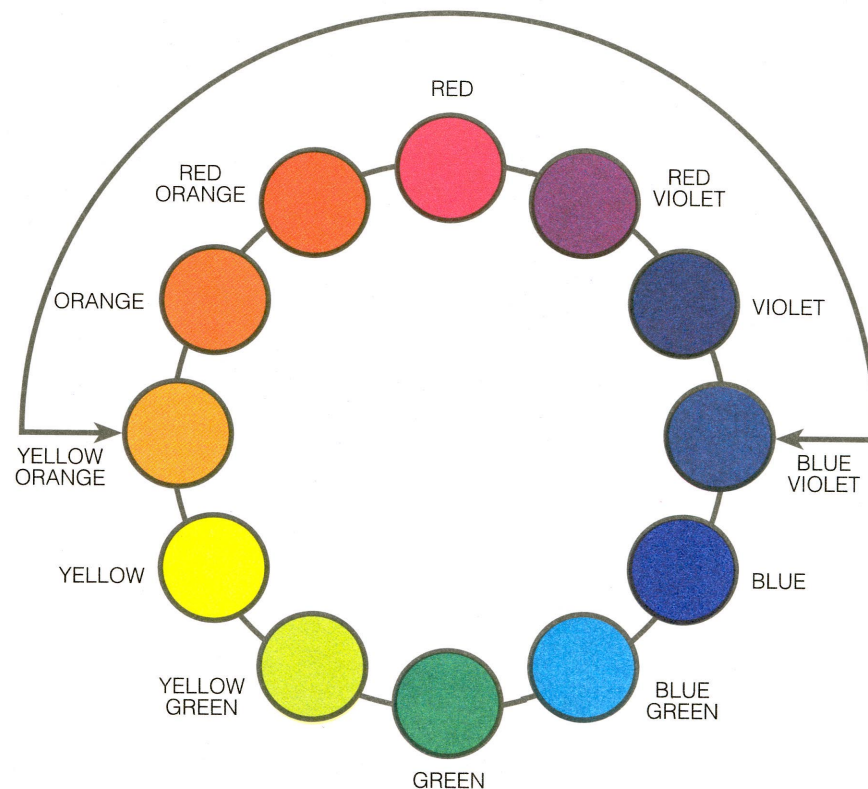
Figure 2-17.—Analogous color.

2-19

Subtractive Theory of Color, Continued

Complimentary color schemes

Complimentary color schemes, sometimes known as harmonies of contrast, conspicuously introduce opposite colors on the color wheel. Complimentary color schemes peak interest but, equal amounts of complimentary colors distract instead of focus. To maintain harmony in complimentary color schemes, use unequal areas, neutralize one color with another, place the primary color as the center of interest and the compliment for the background, contrast light values against dark values, or place dull colors against bright colors. This will give variety to color schemes and create interest.

Figure 2-18 is an effective complimentary color scheme using the compliments of orange and blue.
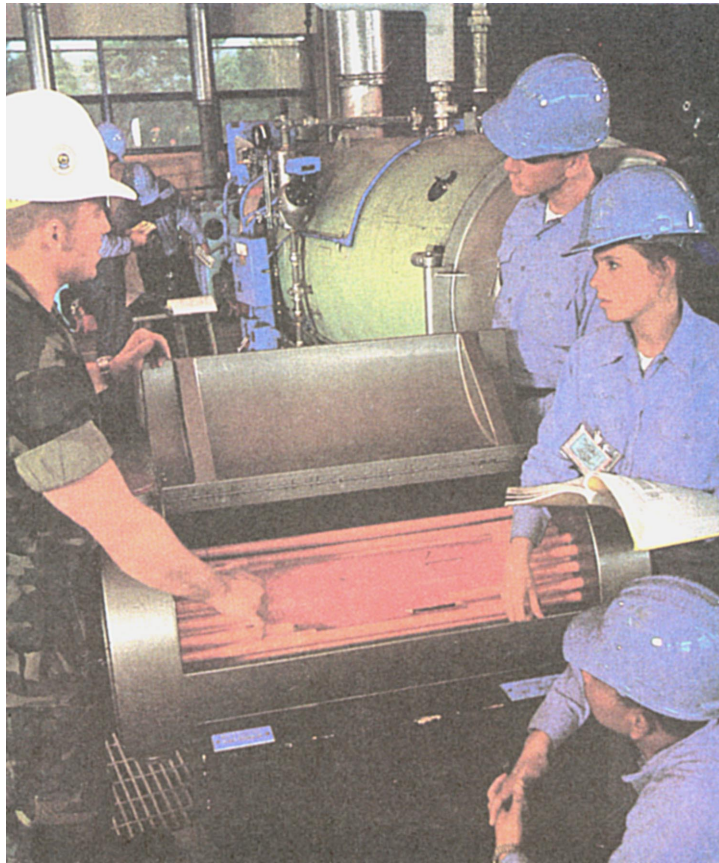

Figure 2-18.—A complimentary color scheme.

Subtractive Theory of Color, Continued

Split compliment color schemes

Split compliments are colors on either side and exclusive of the true compliment.   They are approximate compliments. Split compliment color schemes 'appear more pleasing than complimentary color schemes.   If you base color schemes on a color and its split compliments or on hues mixed from them, you have a wide range of hues. None of these hues will be brighter than the color itself and the split compliments in their full intensity. If you find this range of hues limiting, select the next removed set of split compliments.

Triad color schemes

Triad color schemes use three colors equally spaced on the color wheel. Triad color schemes do not guarantee harmony. Using the three primary colors in a triad color scheme is discordant for each color competes for viewer attention. To create harmony in triad color schemes, select one hue as dominant and mix a little of it with the other two.

Figure 2-19 is a photograph displaying a triad color scheme with red dominant and mixed with the other two colors.

Figure 2-19.—Triadic harmony.

Subtractive Theory of Color, Continued

Set palette

A set palette is a collection of pigments to which a small amount of one color or grey has been added to each one. The advantage of this is to achieve color harmony and unity. It also restricts the beginning painter to a predetermined set of colors. Adding greys or one dominant hue to all other colors will have the greatest effect on the complimentary of the added color. Adding one color to light areas and one color to dark areas will also create harmony and unity. When you want to emphasize one color in a picture, add the same color to all other colors except the color you want to emphasize.

Color characteristics

Color is said to have warm or cool characteristics. Warm and cool colors are qualities of hue rather than value or intensity. Our experiences and how we feel about certain colors determine their perceived temperature characteristics. You may use the warmth or coolness of colors to suggest the location of an object or to give pictures a striking contrast. Any hue may be cooled by adding blue or warmed by adding yellow. To add realism to pictures, paint the planes receiving direct sunlight with warm colors and the shadow planes with cool colors. Look at a color wheel. Note that it is split nearly in half by hues containing reds, oranges, and yellows associated with heat, flame, or sunshine. The other half of the color wheel contains greens, blues, and violets, which relate to water, sky, and ice.

Figure 2-20 illustrates how a 12-hue color wheel is split between colors with warm and cool characteristics.
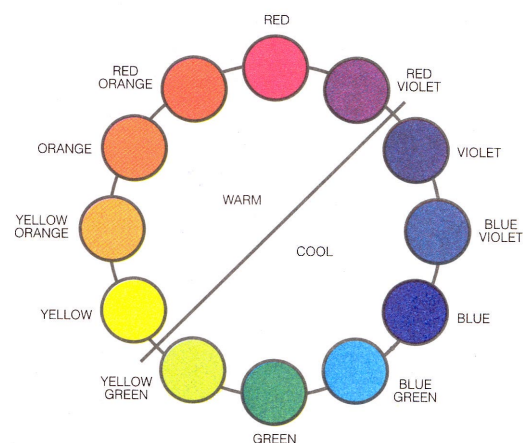
Figure 2-20.—Warm and cool characteristics.

Subtractive Theory of Color, Continued

Color influence   Three factors affect hue, value, and intensity when you see a colored object. These three factors are (1) the local color of the object, (2) the light source which illuminates it, and (3) any color reflecting surfaces near the object. By understanding what happens to color when influenced by other colors, you can use pigments to more effectively portray natural color.

Local color   Local color is the color of an object that is not modified by light, reflection, weather, or distance. Local color is sometimes referred to as true color. Even the spot of color in figure 2-21 reflects some light that creates highlights.

Figure 2-21 is a spot of color.

Figure 2-21.—A spot of color.

Subtractive Theory of Color, Continued

Illumination   The light source that illuminates an object affects the local color of that object. The cool light of northern exposures, early morning, or dusk tends to cool local color. The intense heat of high noon or direct sunlight warms local color.

Figure 2-22 shows the effects of warm and cool illumination on local color.
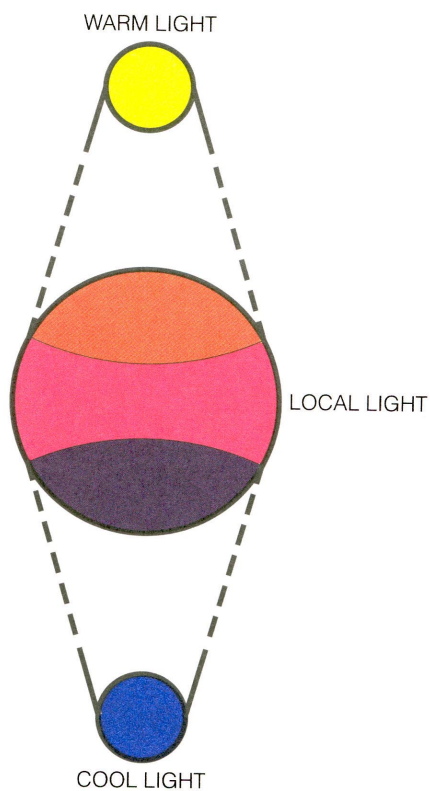
Figure 2-22.—The effects of warm and cool illumination on local color.

Subtractive Theory of Color, Continued

Adjacency   Adjacency, or color reflecting from pigments or surfaces near the object also affects local color. Colors placed side-by-side will modify each other. Complimentary colors placed side-by-side will seem more intense than if they stood by themselves. Also, intense color will seem brighter and more intense against a greyed color (a color that contains neutral grey or complimentary color) than it will against a color of similar high density.   For this reason, do not compare color on your palette. Compare colors as you paint and make adjustments as you work. In the following illustration, notice how reflecting color from the computer monitor affects the faces of the Sailors.

Figure 2-23 illustrates how the reflected color of the computer screen affects the faces of the Sailors.

Figure 2-23.—Adjacency or reflected color warms the faces of these Sailors.

Subtractive Theory of Color, Continued

Color effects   Color affects the emotions and psychological responses of people.   Some
generally accepted color-emotion relationships are contained in the following
table.

Color	Emotion
Dark cool	Strength, restraint
Dark warm	Dignity, power
Light cool	Freshness, calmness
Light warm	Gaiety, excitement
Yellow	Warmth, brilliance
Red	Gaiety, fear, alarm, warmth, anger, excitement
Orange	Sparkle, warmth, autumn
Blue	Quietness, serenity, coolness, joy, emptiness
Green	Rest, freshness, safety, summer
Violet and black	Sadness, mystery, grief, suspense, disgust

Subtractive Theory of Color, Continued

Distance

Distance, usually called aerial perspective or color perspective, uses colors to simulate distance and depth in pictures. To create the impression of depth in pictures, reduce the intensity and warmth of colors as they recede into the horizon. Warm colors appear nearer to the viewer than cool colors. Another method to imply distance is to grey or reduce the intensity of colors as they recede.

Figure 2-24 shows how colors of reduced intensity, also colors warmed by yellow, create a sense of depth and distance.

VIEW A

VIEW B
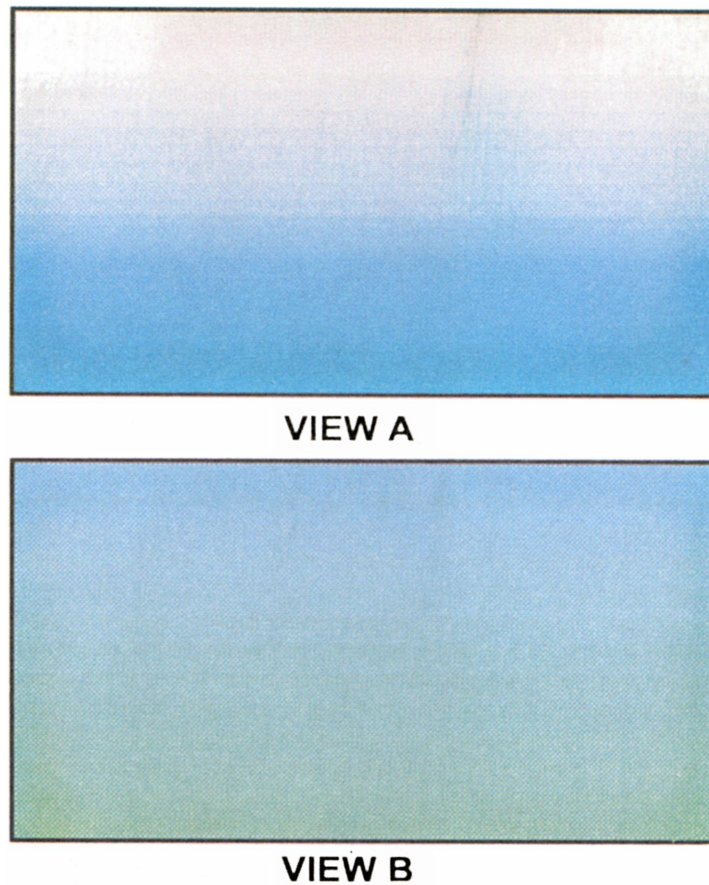
Figure 2-24.—Creating depth: A: By reduced intensity; B: By colors warmed with yellow.

Subtractive Theory of Color, Continued

Luster

Luster is soft, reflected light that appears radiant or brilliant. To create a lustrous effect, use slightly shaded hues suppressed uniformly in value with black. Use pure hues for smaller areas of a painting. The suppressed colors appear natural enough; although slightly dark, the pure colors will appear exceptionally brilliant in comparison. Another technique for creating luster is to paint all colors normally, then airbrush a thin layer of translucent black over the entire painting. Repaint highlights with pure color. A third technique for creating luster in paintings is more direct. Prepare a three- or four-step low-key value range from purity to near black for each basic hue. Paint the image directly on a dark background. In the figure 2-25, a low-key value range in blues and violet accentuates a brilliant, warm, yellow highlight.

Figure 2-25 shows a lustrous view of a submarine and ships.

Figure 2-25.—Luster created through shades of violet and highlights of intense tints of yellow.

Subtractive Theory of Color, Continued

Iridescence   Iridescence is a rainbow-like display of color such as seen in a soap bubble, an opal, or in mother-of-pearl. Iridescence is softer and more subtle than luster and has an illusive quality that uses diffraction to split spectral hues. The colors of iridescent objects change in value and hue when seen from different angles. You can create the illusion of iridescence by uniformity suppressing slightly shaded hues uniformly in value with grey.   To create iridescence, prepare a series of medium value tints between purity and white. Keep tints clear, avoiding greyness or darkness. Paint as you would normally. When finished, airbrush a delicate coat of translucent pale grey over the entire painting until the painting appears misty. Replace touches of pure hue. Another method of creating iridescence is to mix a series of clean tints and add equal amounts of medium grey to each. Continue to grey each hue creating three or four steps from a clean hue to neutral grey. Paint as you would normally, using pure tints as highlights. This technique will establish a general overall grey cast and lend unusual iridescence to the minor areas occupied by the clean tint.

Subtractive Theory of Color, Continued

Luminosity

When objects or paintings appear to have an inner glow, they are said to have *luminosity.* Light appears to come from within. To create luminosity in paintings, surround rich, pure hues with dark values or their opposite on the color wheel. If the color is not pure, the results may be disappointing. Several conditions contribute to the success of luminous painting, (1) the luminous area must be small, (2) the color that is to be luminous must be purer than surrounding color, (3) the color that is to be luminous must be of a higher value than surrounding color, (4) the luminous color must prevail over all other colors, and (5) other objects in the painting must appear soft and hazy as if the viewer's vision is blurred by the luminous object.

Figure 2-26 shows how light from the sparks thrown off by the grinder give this photograph a luminous glow.

Figure 2-26.—Luminous sparks glow from this picture.

Subtractive Theory of Color, Continued

Color mixing   You will seldom use color straight from the tube. It is important to develop good color mixing habits to make sure that your colors are clean and not greyed.

Here are a few tips to help you in preparing color mixes:

● Clean your brush before you pick up any color.

● Prevent paint from seeping up to the metal ferrule when you use your brush to mix paint. Residue paint rots brush bristles and may stain other pigments you mix.

● Use a clean palette knife to pick up yellow. Yellow is the most sensitive color on the palette. Using a brush with residue from another color will stain yellow pigment.

● Keep mixtures simple. Use only two or three colors plus black and white. More color will only muddy or grey your mixtures.

● Use white carefully. White paint neutralizes other colors and may appear chalky or washed out.

● Mix dark colors into lighter colors to economize paint and effort. It takes less paint to mix green by mixing a dab of blue into yellow than to mix a quantity of yellow into blue.

● Darken a color by using its compliment. Compliments mixed in the correct proportions become neutralized greys. These greys may be warm or cool.

● Dip a brush into two colors and, without mixing or palatting the brush, apply the pigments directly to the painting. This technique is a form of broken-color painting.

● Keep two jars of water handy. Use one jar to rinse color from the brush and the other jar of water will remain clear for mixing.

Process Color

Introduction	Continuous-tone artwork in full color and intended for reproduction is better left to the camera person for photographic separation. Better reproductions result from using colors in the original that are similar to the colors of ink the printer uses. Master the processes used in preparing continuous-tone originals for color reproduction.
Color reproduction	The two categories of color reproduction methods are process color and flat color.
Process color	Process color is the four-color separation and printing process of continuous-tone masters requiring photographic separation of each of the three primaries plus black. The three primary process colors are cyan (blue) abbreviated (C), yellow abbreviated (Y), magenta (red) abbreviated (M). The three primary process colors plus black (K) are the foundation of the CYMK process color theory. The CYMK process color theory uses inks to reproduce color images. Each isolated. color creates a plate which, when printed in turn, reproduces the original in full color.
How process color works	The printer makes separate negatives and separate press plates for each of the primary colors plus black (a total of four) in continuous-tone color art. The camera person may use only three negatives and three plates if the artwork is simple. Since colors photograph as black or shades of grey, the printer uses regular black-and-white panchromatic litho film. A grey scale, photographed along side the artwork assists the camera person in comparing density and contrast for each negative. Negatives should have the same density and contrast or they print out of balance. The photographer uses halftone screens and color filters when shooting color separations. The halftone screen breaks the image into dot patterns. The angle of the halftone screen changes for each color shot. This change in angular position causes the film to record dots that, when printed, overlap. A blue filter records yellow, a red filter records cyan (blue), and a green filter records magenta (red). No filter or a combination of the three filters records black in the original. The filters used by the camera person are not true blue, red, and green. Filters have numerical values based on density and color. Select the filter with the correct numerical value to achieve maximum contrast and density. Overlapping differently colored dots creates secondary and tertiary colors.

Process Color, Continued

How process color works (Continued)

Correct any flaws on the negative and expose and develop the press plates. Pull a proof from each plate in color. This proof is known as a progressive proof. If density and contrast are correct, run the plates on the press in the proper colors of ink.

Figure 2-27 shows separation negatives, progressive proofs, and a print resulting from the four-color process.

1. Yellow printer negative made by photographing the colored copy through a blue filter.

2. Positive plate from the yellow negative.

3. Positive plate from the yellow negative (yellow printer) printed in yellow.

4. Red printer negative made by photographing the colored copy through a green filter.

5. Positive plate from the red negative (red printer) printed in red.

6. The yellow plate overprinted with the red plate.

7. Blue printer negative made by photographing the colored copy through a red filter.

8. Positive plate from the blue negative (blue printer) printed in blue.

9. Combined yellow, red, and blue printings.

10. Black printer negative made by photographing the colored copy through a yellow filter.

11. Positive plate from the black negative (black printer) printed in black.

12. Combined yellow, red, blue, and black printings.

Figure 2-27.—Separation negatives, progressive proofs, and finished four-color image.

Process Color, Continued

Flat color   If the color in the resulting print is simple to separate and appears without modulation, it is called *flat color*. Gradations of tone require the use of shading sheets and are photographed as line art. Spot color and fake color are examples of flat color printing processes.

Spot color   Spot color is a process used when only a small portion of an image requires color. The printer separates color areas by reading instructions attached to the original artwork on an overlay. The DM does not have to separate color on another piece of art. On complicated drawings, the DM creates overlays for each color, registers them to the master, and indicates desired ink color.

Fake color   Fake color, or pre-separated color, also uses overlays to indicate colored areas on line art or continuous-tone art. Place an overlay on the art and define the outlines of the image on the overlay. The printer will strip the separations into color panels and make separate color plates.

Color Electronic Prepress Systems

Introduction   Computers are increasingly present in the work space and many commands have access to digitized systems producing finished graphics. Digitization is also used in the creation of color separations for reproduction. You should be aware of color electronic prepress preparation and some of the serious limitations it imposes.

Color Electronic Prepress System   Color Electronic Prepress Systems (CEPS) are high-end systems that perform all the steps required to create original art and transfer it to a press plate. A CEPS is a component system containing a drum scanner, a digitizing tablet with a cursor or tracing pen, memory, software, a high-resolution color monitor, and an output device to record images.

CEPS scanners   Image and color resolution are primarily controlled by the type of scanner used to scan images. Most CEPS have a drum scanner that scans at high resolution. Images scanned by the drums of CEPS scanners may be imported to a desktop computer system for manipulation and exported back to the CEPS system for final resolution before printing. CEPS drum scanners rotate at high speed. A beam of light passes through or is reflected from copy. An internal photomultiplier tube (PMT) records the image. There is an individual PMT to record each blue, red, and green signal. Each electronic signal is fed to four separate internal computer units (blue, red, green, and black) for color correction. Signal ranges may be manually changed for effect. Corrected signals are then fed to lights that vary intensity to correctly expose film. CEPS scanners accommodate all line art, grey scale scanning, and color.

Desktop Color

Introduction   Some of you have a computer system for a workstation. You should become familiar with color as it applies to computer-generated or desktop color.

Desktop color   Desktop color is computer-generated color or various shades of grey from an IBM (PC) or Macintosh (MAC) computer systems. The color limitations of desktop color are the Random Access Memory (RAM) capacity of the computer, the Video Graphics Array (VGA) card, the scanner, and the monitor.

Memory   Random Access Memory (RAM) determines the speed and power considerations for color. Color displays require more RAM than monochromatic displays. If your computer doesn't have enough memory, you will experience delays in completing jobs that involve color. When adding color capabilities to your desktop system, reevaluate memory capacity and expand it if necessary.

Video Graphics Array (VGA)   Video graphics array (VGA) cards or Super Video Graphic Array (SVGA) cards control the resolution of computer monitors. Monitor resolution is stated in terms of dots per inch (dpi) for MAC monitors or picture elements (pixels) for PC monitors. You may use a VGA with color or black-and-white monitors. The VGA monitor has a resolution of 640 x 480 dpi. Super VGA increases the resolution to 800 x 600 dpi or 1024 x 768 (extended VGA).

Scanners   Scanners scan text and images and record them to memory. The type of scanner determines the resolution of the scanned image. Scanners are classified by image capture capabilities and whether they use the theory of reflectance (opaque copy) or the theory of transmission (transparent copy). There are hand-held scanners, sheetbed scanners, flatbed scanners, overhead scanners, slide scanners, and drum scanners.   Most scanners connected to desktop computer systems use sensing elements called charged-couple devices (CCD). When light strikes CCDs, they retain voltage. The voltage apportions the amount of light striking the sensors and transfers this into reproduced copy. CCD scanners are of lower resolution than the photomultiplier tube scanners of Color Electronic Pre-press Systems.

Desktop Color, Continued

Image capture The three types of image capture are line art, grey scale, and color.

LINE ART: Line art is images that are either black or white and have no gradations in tone. Line art scanners record black as one bit and white as one bit. This is called one-bit or bilevel scanning. Simulating halftones in the scanned image is known as dithering.

GREY SCALE: Grey scale scanning is for continuous-tone art. The scanner assigns grey levels based on the light that reflected from or passing through the original image. Increasing bits per pixel (pixel depth) increases the number of greys recorded and proportionally increases file size. Eight-bit scanners produce 256 levels of grey.

COLOR: Desktop color scanners usually allow 8 bits per spectral primary and 8 bits for black totaling 24 bits of information per pixel. This creates a palette with more than 16 million available colors. Color monitors should be capable of displaying 24 bit color. Convert images scanned as 24 bit color to 8 bits before displaying the image on monitors incapable of displaying 24 bit color.

Color monitors Color monitors display images and text while you work in the document. The resolution and accuracy of a desktop system depends heavily on the quality of monitor. Monitor resolution is defined by dpi (MAC) or pixels (PC).   Screen size is measured diagonally across the monitor face. Large monitors that display a full page or a two-page spread horizontally are ideal for the DM and this type of monitor accuracy is often called WYSIWYG (pronounced whizzywig), an acronym for What You See Is What You Get. WYSIWYG monitors and appropriate software allow the DM to create and correct art and copy with unparalleled accuracy. What you see on the horizontally oriented screen is exactly what the hard copy should look like. Vertically oriented monitors are called portrait monitors.

Summary

Review

This chapter provides an elementary explanation of light and light characteristics and a brief description of how light responds to different media, reflects off of unlike surfaces, and what this does to local color. This chapter provided an introduction of basic color theories and showed fundamental differences between additive and subtractive color theories. Process color and the technologically advanced CEPS systems are another form of color creation using inks instead of light or pigments. Desktop color is color derived from light and modified by digitization. Neither color nor black-and-white would be possible without light.

Comments

People are intrigued by color and gravitate toward it. Sometimes, poor or mediocre compositions receive praise solely on the fact that they are colorful. This is particularly true in photographs. When used correctly, color can be powerful and persuasive. Learn how to use color. Don't rely on adding color to revive poor illustrations. As an Illustrator Draftsman, you should strive to create images that remain strong with or without color. A true test of sophisticated composition is tonal clarity in black-and-white reproductions.